



Revolutionary Advances in Large-Scale Manufacturing **Polymer Derived Ceramic** Structures in **Quantities of One** 



#### **Discussion Points**

- Brief History of the Company
- Evolution of UMS Technology
  - Overview of Technology



# Brief History of the Company

- Invention
- Business
- Partnering



#### 3 Inventors Bulk Ceramic

**Arnold Hill** United Materials and Systems, Inc

**Dr. Weifeng Fei** United Materials and Systems, Inc

**Dr. Linan An, UCF** Advanced Materials Processing &

Analysis Center (AMPAC)

University of Central Florida

"Method for Synthesizing Bulk Ceramics and Structures from Polymeric Ceramic Precursors," U.S. Patent Application Serial No. 12/372,297



# 3 Inventors Hybrid Bulk Ceramic

**Arnold Hill** United Materials and Systems, Inc

**Dr. Weifeng Fei** United Materials and Systems, Inc

Mark Tellam, P.E. United Materials and Systems, Inc.

"Methods For Synthesizing Bulk, Composite and Hybrid Structures From Polymeric Ceramic Precursors as well as other Polymeric Substances and Compounds" U.S. Patent Application Serial No. 12/584,213



#### **Business**

**Arnold Hill, President** 

Mark Tellam, P.E., Business Development

The core business of UMS is the development and application of bulk ceramic and combinations of PDC which build upon bulk ceramic.

UMS is engaged in:

- •Researching Derivatives and Applications of PDC's and Bulk PDC;
- •Developing Intellectual Property (IP) for Derivatives and Applications identified;
- Conducting Verification Studies for such Derivatives and Applications;
- Developing Turn-Key Production Solutions for such Derivatives and Applications;
- •Working with End Users to Validate these Production Solutions to their Applications.
- Manufacturing Hybrid PDC Components



#### **Revolutionary Advances in Manufacturing Polymer Derived Ceramic Structures**





#### Business Development with FLHTCC



Florida High Tech Corridor Council (UCF, USF, UFL) Provided External Matching Grant



Florida Manufacturing Extension Partnership (FMEP) (NIST\_DOC)





### **UCF Technology Characterization**



UCF Advanced Materials
Processing & Analysis Center
(AMPAC) (UCF College of Engineering)

- AES/SAM Physical Electronics 600
- EPMA JEOL 733 Super Probe
- PicoSPM (STM, AFM) Molecular Imaging
- SEM Hitachi 3500N
- SIMS CAMECA IMS-3F Ion Microscope
- SIMS PHI Adept 1010 Dynamic System
- RBS Geneal IONIX 1.7 MU Tandetron

- ESCA (XPS) Physical Electronics 5400
- FIB FEI 200 TEM
- TEM FEI Tecnai F30
- XRD Rigaku D-MaxB
- XRD II Rigaku D-MaxB
- Zeiss ULTRA-55 FEG SEM

http://www.ampac.ucf.edu/default.asp



# Brief History of the Technology

- Coating Applications
- Nano Technology Extensions
  - Bulk Material Applications
- Hybrid Bulk Material Applications



# Brief History of the Technology

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•2001 KiON

•2007 UMS

Table 7.2 Commercial available precursors (not complete).						
Precursor name	Resulting ceramic system	Important properties*	Company			
KION HTT 1800	SiCN	Liquid	Clariant GmbH			
KiON HTA 1500 slow or rapid cure	SiCN	Liquid	Clariant GmbH			
KiON ML33	SiCN	Liquid	Clariant GmbH			
KiON ML66	SiCN(O)	Liquid	Clariant GmbH			
KiON ML20	SiCN(O)	Liquid	Clariant GmbH			
Ceraset PURS 20	SiCN	Liquid	Clariant GmbH			
Ceraset PSZ 20	SiCN	Liquid	Clariant GmbH			
Ceraset Ultra	SiCN	Meltable solid	Clariant GmbH			
NL 120A-20	SiN	Solution	Clariant GmbH			
NN 120-20	SiN	Solution	Clariant GmbH			
SMP-10	SiC	Liquid	Starfire Systems			
MCs	SiC	Moldable	Starfire Systems			
CVD-2000	SiC	Solution	Starfire Systems			
CVD-4000	SiC	Solution	Starfire Systems			
SOC-A35	SiCO	Meltable solid	Starfire Systems			

Ref: Ceramic matrix composites: fiber reinforced ceramics and their applications edited by Walter Krenkel



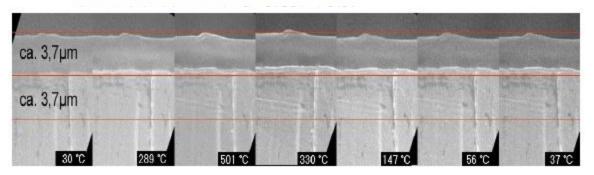
### **Coating Applications**

Clear
Anti Corrosion
Gas Barrier
Easy to Clean
High Temperature

Ref: Clariant

Corrosion protection coatings





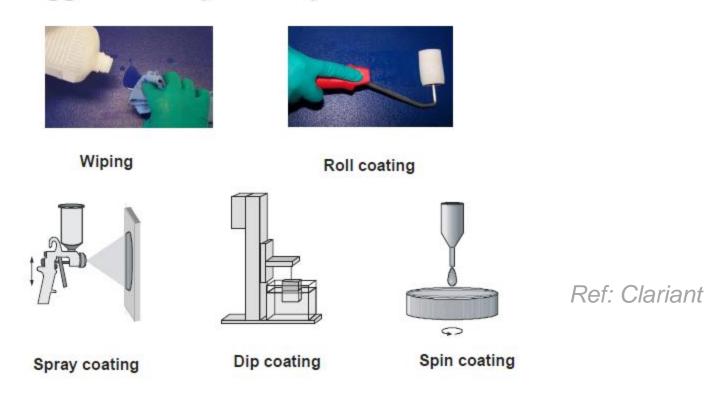
ESEM (environmental scanning electron microscopy) Experiment:

Curing of polysilazane layer on a metal surface: dimensional stability



# **Coating Applications**

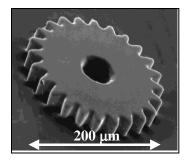
Application of PZane formulations

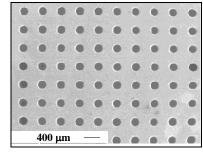




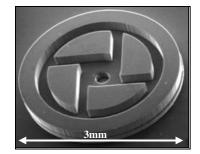
### Nano Technology Extensions

Lithographically
Defined
Structures &
Components





Micro Fluidics



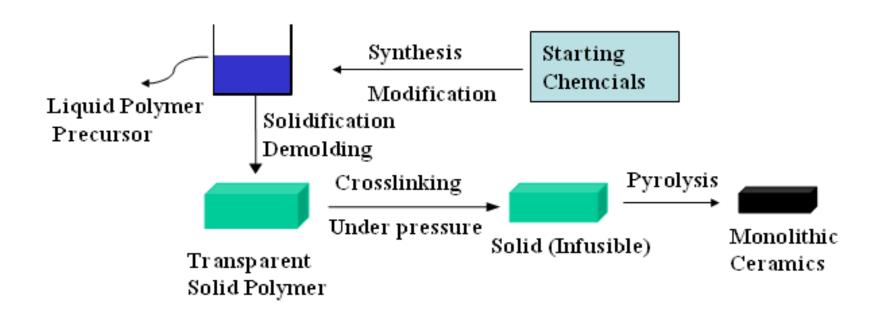
Ref: UCF AMPAC



#### 'Meso' Process Discussion

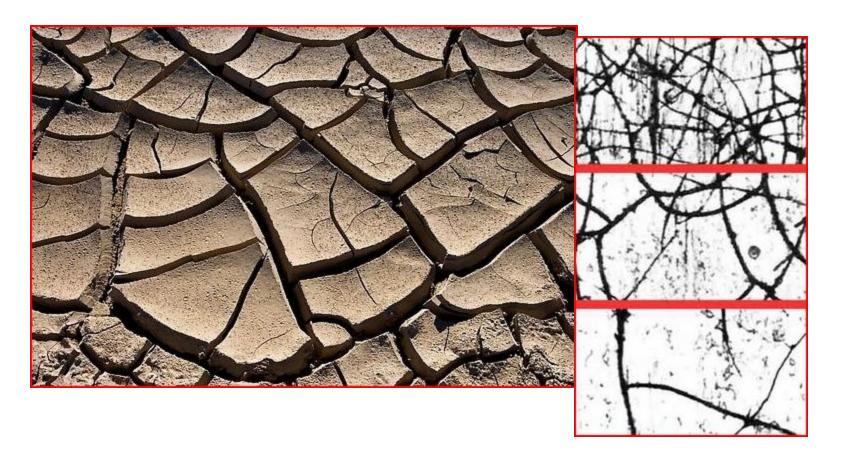
Polymer Derived Ceramic Precursors = Fetal Ceramic

Working with Fluid, Curing with Heat and/or Light





# Subject to: Critical Gas Diffusion Path Length & Differential Strain



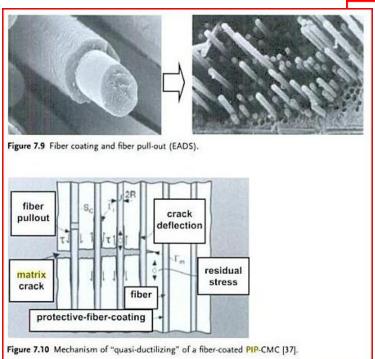


# Ceramic Matrix Composite Applications





#### Subject to: Polymer Impregnation and Pyrolysis



Ref: Ceramic matrix composites: fiber reinforced ceramics and their applications edited by Walter Krenkel

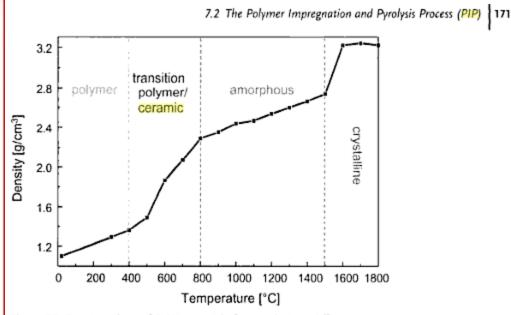


Figure 7.7 Density values of SiCN material after pyrolysis at different temperatures.

increase in density was observed up to 400°C because of a higher degree of cross-linking. The strongest increase in density was measured during the transition from the polymer into the ceramics in the temperature range from 400 up to 800°C. The further compaction effect up to 1500°C is due to rearrangements in the amorphous state. The last increase in density at temperatures higher than 1500°C in Figure 7.7 is based on the decomposition of the SiCN ceramic by the loss of nitrogen and the formation of crystalline SiC.

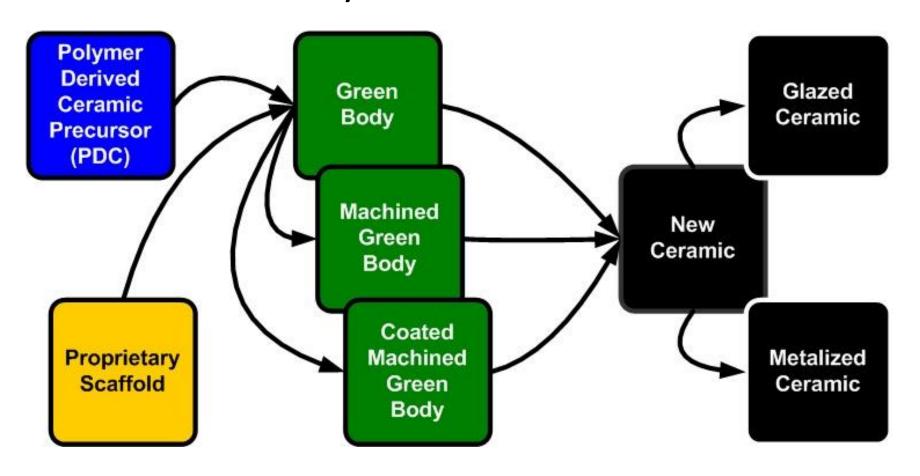


# Evolution of UMS Technology... the First and Only Bulk PDC Material



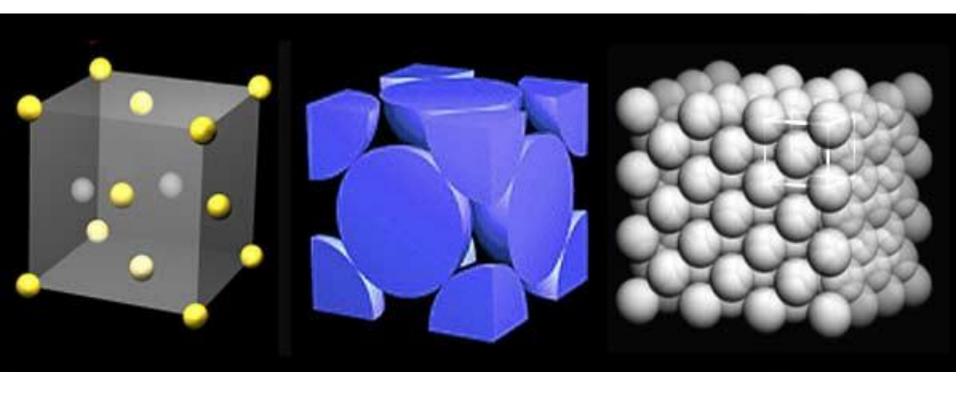


#### The First and Only Bulk Material Process Flow





# The First and Only Bulk Material Principle





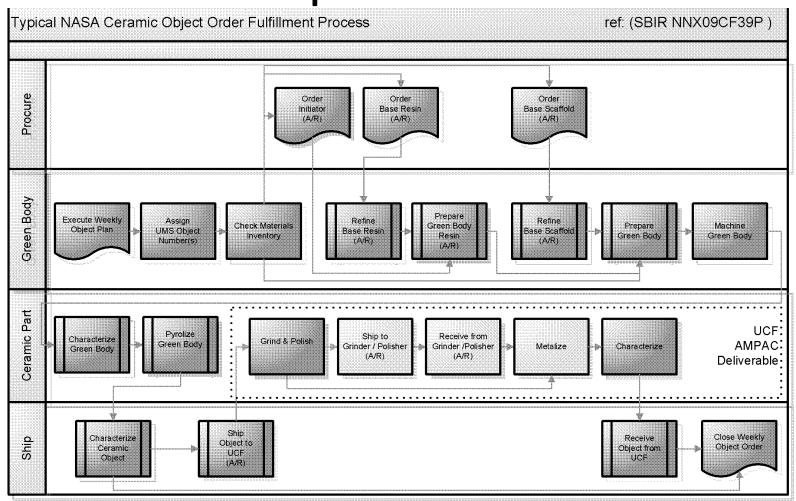
#### NASA Deliverable July 2009

Process Overview

- Green Body Development
- Ceramic Mirror Substrate



#### **ISO Compliant Processes**



**United Materials & Systems Incorporated** 

Covered by US Patents, Trademarks , Copyrights and Employee Confidentiality and Non Compete Agreements

ISO PROCESS SHEET: 080628\_0001\_00\_05

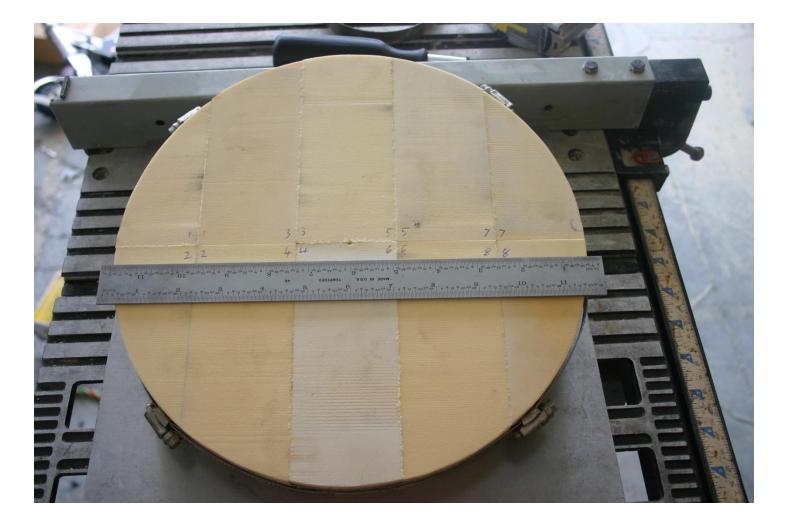
**CONFIDENTIAL PROPRIETARY** 

United Materials and Systems, Inc June 2010

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#### 25 cm Scaffold





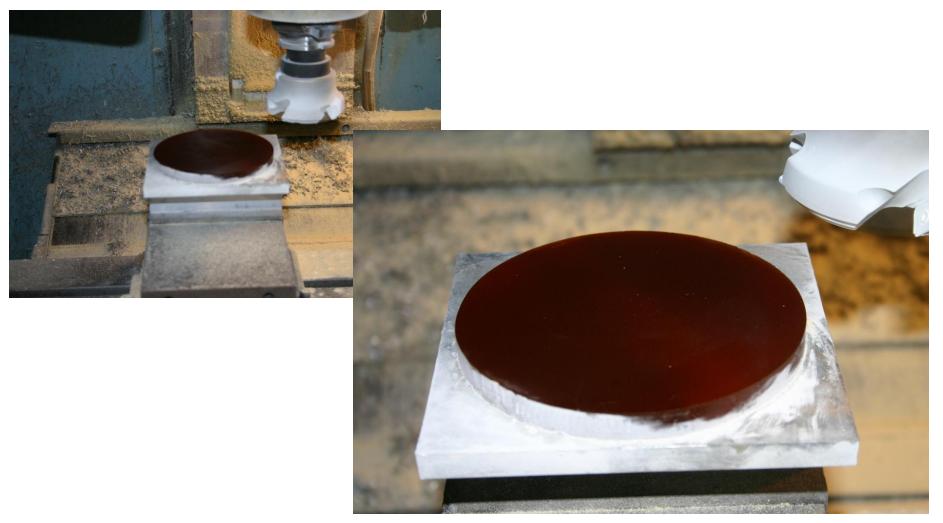
Pick a PreCursor, any PreCursor





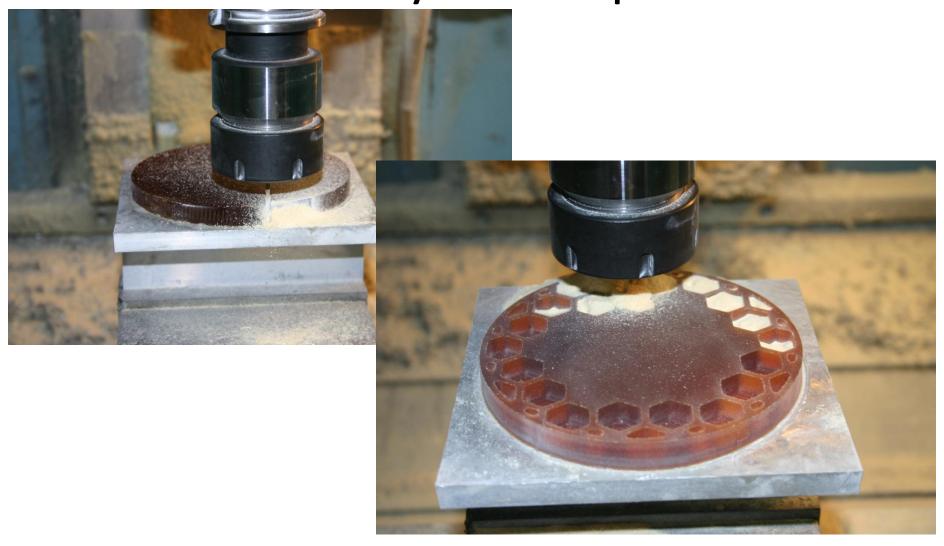
- •Green Body (Ceramic Children)
- Machining is performed to yield near net shape, while plastic
- No Tooling
- Low Energy Consumption



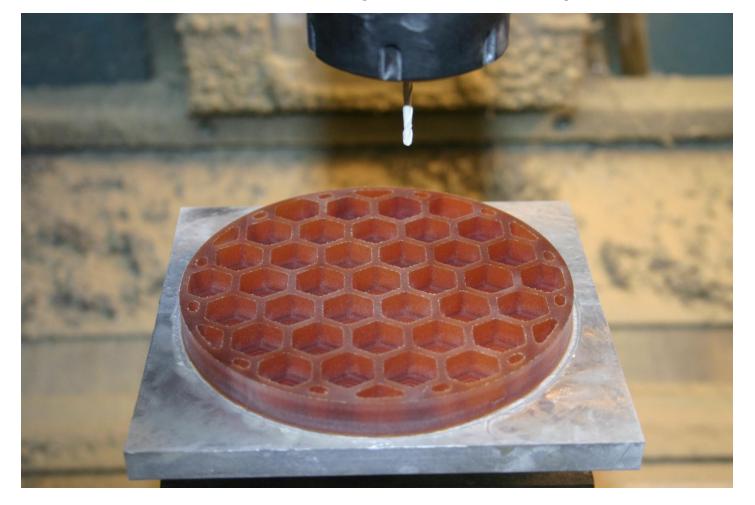


United Materials and Systems, Inc June 2010











# From Green Body to Ceramic





#### Ceramic Mirror Substrate

- Unique Adult Ceramic Processed to 800-1000 (deg C)
- Less Energy Consumed than with Sintering
- Grinding Polishing Accomplished Relatively Easily
- Metalizing Exploring Feasibility and Options



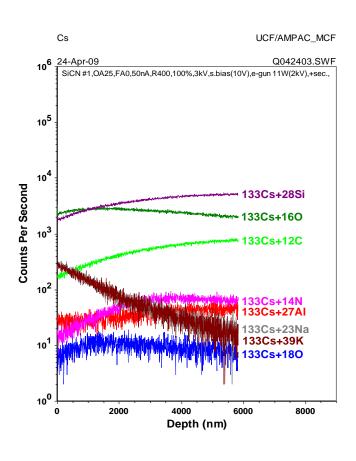
#### **Ceramic Mirrors**

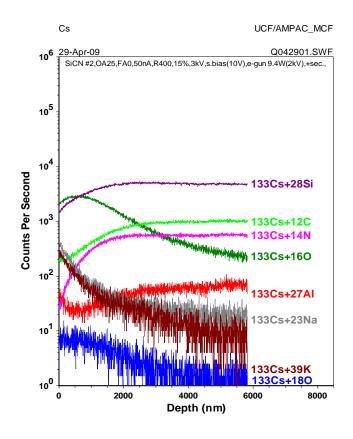
15 cm Mirror Substrate





#### **Ceramic Mirrors**







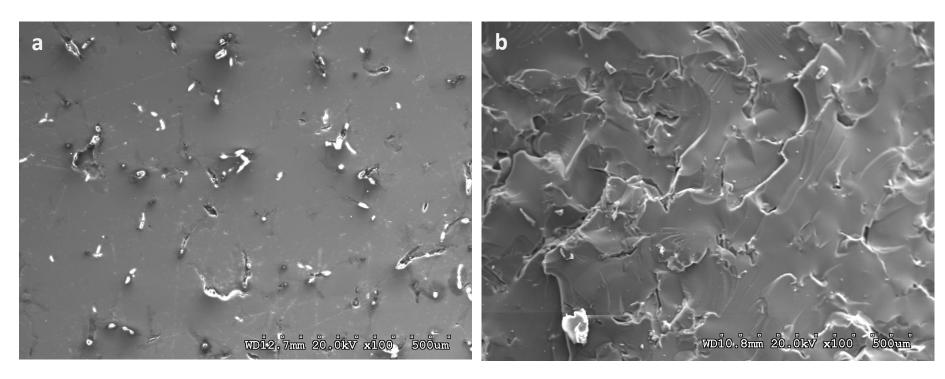




Retort 3



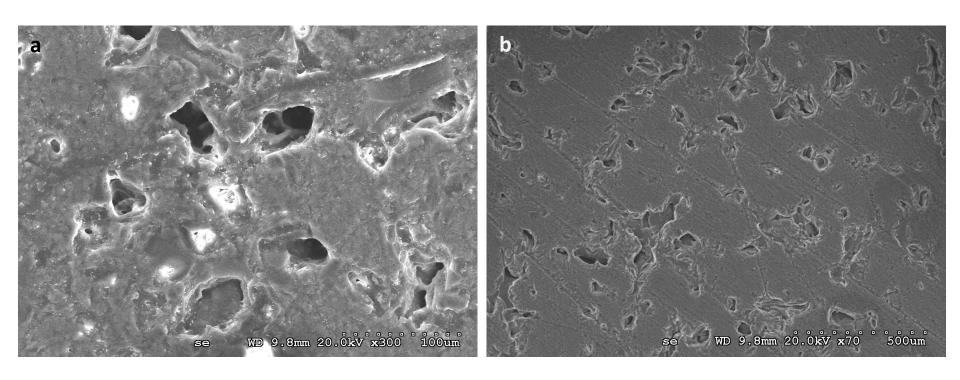
#### Post Phase One SBIR Development Activities Hybrid PDC Component Development



Young Green Body Cross Sections



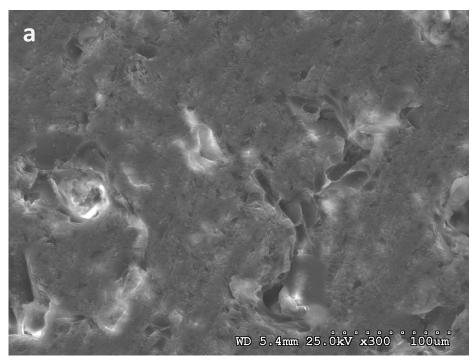
#### Hybrid PDC Component Development

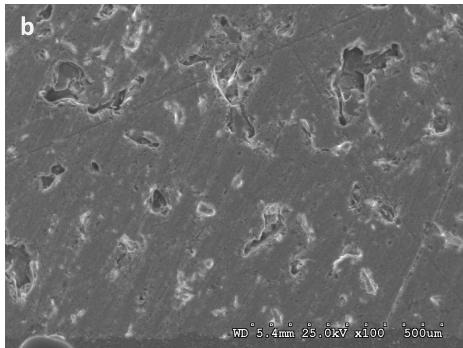


Teenager Green Body Cross Sections



#### Hybrid PDC Component Development



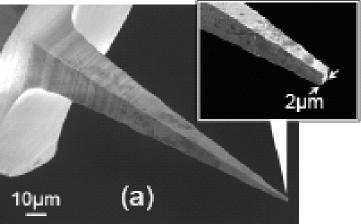


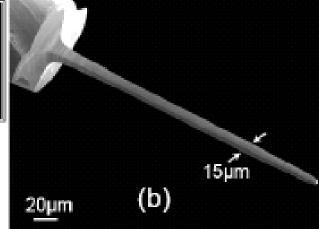
Monolithic Bulk Solid with Fully Dense Surface Cross Sections





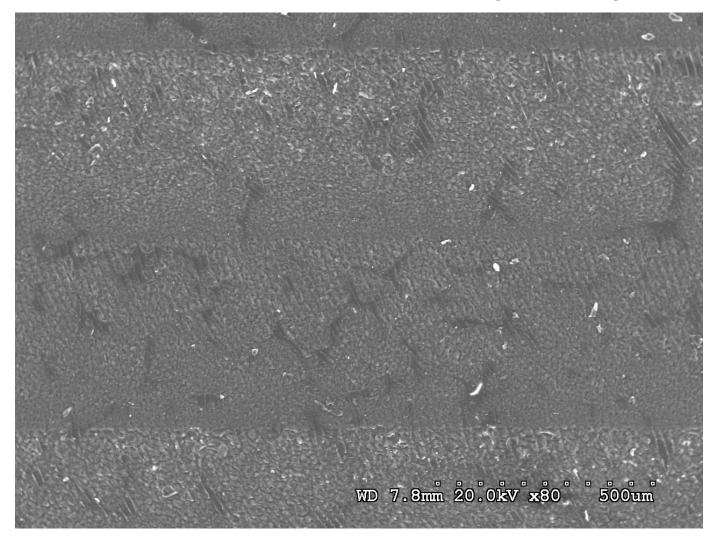
# Machinability Process Capability Studies







# Machined Green Body Properties





# More Parts, More Applications, Predictive Modeling





More Equipment, More Partners, New Location





### Overview of Technology

- No Tooling
- Low Volume, High Mix Manufacturing Model
  - Low Total Cost To Part
    - Monolithic Structure
  - •Isotropic Structural Properties
    - Homogeneous Material
  - Component Region Appropriate Density
  - Pre-Ceramic Alloying => Ceramic Alloying



#### **United Materials & Systems Inc**

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Contact UMS for your 'Rapid Manufactured Ceramic' Solution